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Use of a steerable needle for CT-guided nerve plexus blockade

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Abstract

Purpose: Demonstrate the use of a new steerable needle for CT-guided neural plexus blockade to avoid traversing the kidneys.
Materials and methods: Retrospective evaluation of 23 consecutive CT-guided neural plexus blockade procedures in which a new steerable needle was used in the last 13 and compared with the prior 10 procedures in which a standard needle was used.
Results: Use of the steerable needle was beneficial to reach the target area without traversing a kidney or other organs in 6/13 (46%) procedures; in the other 7 procedures there was no benefit. A kidney was traversed in 0/13 procedures performed with the steerable needle. In contrast, a kidney was traversed in 4/10 (40%) procedures using a standard needle ($P = 0.02$). There was no significant difference in clinical benefit ($P = 1.00$) or complications ($P = 0.56$) between procedures using the steerable needle versus a standard needle. Three complications were observed (1 major and 2 minor) felt to be related to the injection and not the needle type.
Conclusions: The utility of a steerable 21-gauge needle during neural plexus blockades was found to allow for avoidance of the kidneys when compared to a standard (non-steerable) needle. Interventional radiologists may find this needle and its future iterations useful for neural blockades, as well as other procedures, when intervening structures need to be avoided.
Level of evidence: Level 3, Non-randomized controlled cohort.

Key words: Nerve block—Pain management—Palliation

Abbreviations

CT	Computed tomography
IVC	Inferior vena cava

CT-guided neural plexus blockades, either temporary or permanent, are a mainstay of pain control. The first use of computed tomography (CT) guidance was reported in the early 1980s [1, 2]. Improved pain control after celiac plexus blockade has been reported to be 73%–100% for malignant pain and 37%–59% for pain associated with benign disease [3–5]. Although less effective for benign disease, neurolysis of the aorticorenal ganglia on the symptomatic side can often treat the pain from autosomal dominant polycystic kidney disease [6–8]. Temporary or test blockades can be performed using long-acting anesthetic agents (eg., ropivacaine, bupivacaine) with a corticosteroid. So-called permanent blockades or neurolysis can be performed with caustic agents (eg., phenol) or, more commonly, absolute alcohol.

Small needles (21- and 22-gauge) are used, and may result in traversing a kidney or other structures. Avoidance of the kidneys or IVC during procedures is always preferable and could save a patient a complication or discomfort. However, when small-gauge needles are used, complications are rare, notwithstanding the alcohol injection [9, 10].

A new steerable, 21-gauge needle became available in late 2015. Subsequently, this needle was used for all celiac and aorticorenal plexus blocks at our institution. We report the use of this steerable needle in 13 sequential procedures and compare outcomes to 10 prior procedures using standard needles. In particular, we evaluated whether the steerable needle was associated with decreased incidence of traversing the kidney, the most likely organ to obstruct needle trajectory, and whether the use of the steerable needle affected pain palliation

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outcomes or complications. Avoiding the kidney, in itself, is not often clinically important with small needles, but we aim to demonstrate the ability to avoid an intervening organ or structure using this steerable needle, for those instances when it may be clinically relevant for a procedure.

Materials and methods

This retrospective analysis was approved by the institutional review board and was in compliance with the Health Insurance Portability and Accountability Act; a consent waiver was obtained. A retrospective analysis was performed of sequential CT-guided celiac plexus and aorticorenal plexus blockades from February 2014 through December 2016 at a single institution. Imaging, imaging reports, and clinical rationale and follow-up were reviewed. Type and size of the needle were recorded. The reasons for the procedure, the blockade type (temporary or permanent), and clinical benefit were also recorded. A procedure was deemed clinically beneficial when the health record showed documented decreased pain (drop of 3 or more points on a scale of 1–10, with 10 the most pain) or the use of analgesics (decrease by at least half the previous dose) for at least 1 month after the procedure for permanent blocks and at least 3 days for temporary blocks. Complications were recorded and rated using the Society of Interventional Radiology criteria [11]. Images of the needle placement were reviewed to determine whether the steerable needle, when used, was beneficial and whether either kidney was traversed by the needle.

A blockade was considered "temporary" when performed using a long-acting local anesthetic (ropivacaine or bupivacaine) and betamethasone for short term relief or for diagnostic purposes. A blockade was considered "permanent" when dehydrated absolute alcohol (10–15 mL total) was used as well as a long-acting local anesthetic and betamethasone, with intent to achieve neurolysis and long-term pain relief. Agents were mixed with a small amount (1–2 mL) of iodinated contrast agent (iopamidol 41%; Bracco Imaging SpA). All procedures were performed using CT guidance from a posterior approach (spiral scans and CT fluoroscopy; Optima CT660, GE Healthcare), with the patient prone, by a sole operator who had more than 20 years' experience performing celiac blockades. All procedures were performed with monitored mild to moderate procedural sedation. A steerable 21-gauge, 17-cm needle (Morrison; AprioMed), or a 21-gauge, 10- or 15-cm "standard" needle (Chiba; Cook Medical) was used. The steerable needle allows the operator to curve the tip of the needle using a lever attached to the internal stylet. The stylet has an internal wire component exiting through a hole about 4 cm from the tip and then attached near the tip. Turning the lever pulls the wire and bends the tip. When outside the needle, the stylet bending looks like a sphincterotomy wire or the string on an archer's bow (Fig. 1A, B). When used inside the needle, it will cause the tip to bend (Fig.1C). The direction of the curve is toward the lever and can be adjusted by rotating the needle.

The Fisher exact test (SAS software version 9.3; SAS Institute Inc) was used to test whether traverse of the kidney, complications, or benefit from the block significantly differed between the standard needle and steerable needle techniques. Because the definition of *beneficial* differed temporally for temporary (≥ 3 days) and permanent blocks (≥ 1 month), beneficial outcome was further stratified by temporary versus permanent block.

Results

In total, 23 procedures were performed for 18 patients [10 women (56%); median (range) age, 45 (19-87) years], with 2 procedures for 1 patient targeting the right aorticorenal plexus and 21 procedures on 17 patients targeting the celiac plexus (8 were bilateral). Ten procedures were temporary blocks. The other 13 procedures were permanent blocks. Twelve procedures were performed for pain due to advanced metastatic malignancy, and 11 were performed for pain from benign disease.

The steerable needle being evaluated was used in the last 13 consecutive procedures of the 23 total procedures, beginning in December 2015. Retrospective review of the imaging found that in 6 of the 13 procedures (46%), use of the steerable needle was beneficial to reach the target area without traversing a kidney, renal vessels, or IVC, or to manipulate around ribs or the spine (Figs. 2 and 3). In the other 7 procedures there was no benefit or no need to "steer" the needle demonstrated. A kidney was traversed in none of 13 procedures performed with the steerable needle. In contrast, a kidney was traversed in 4 (40%) of 10 procedures with a standard needle, which was a statistically significant difference ($P = 0.02$) (Figure 4). At clinical follow-up, 8 (62%) of the 13 blocks using the steerable needle and 6 (60%) of the 10 blocks using standard needle were deemed clinically beneficial ($P = 1.00$).

One major and two minor complications occurred that are known potential complications of the neurolysis injection itself. Diarrhea, nausea, vomiting, and hypertension were observed 3 days after the procedure of one patient, who was admitted for 5 days to control the adverse symptoms. This occurrence was considered a major complication, considered class D [unplanned increase in level of care, prolonged hospitalization (> 48 h)] by the Society of Interventional Radiology criteria [11]. A permanent block had been performed using the steerable needle without traversing kidneys or other structures. The other 2 patients had minor complications considered class B (ie., nominal therapy, no consequence, and no hospitalization) by the same criteria. Both of these pa-

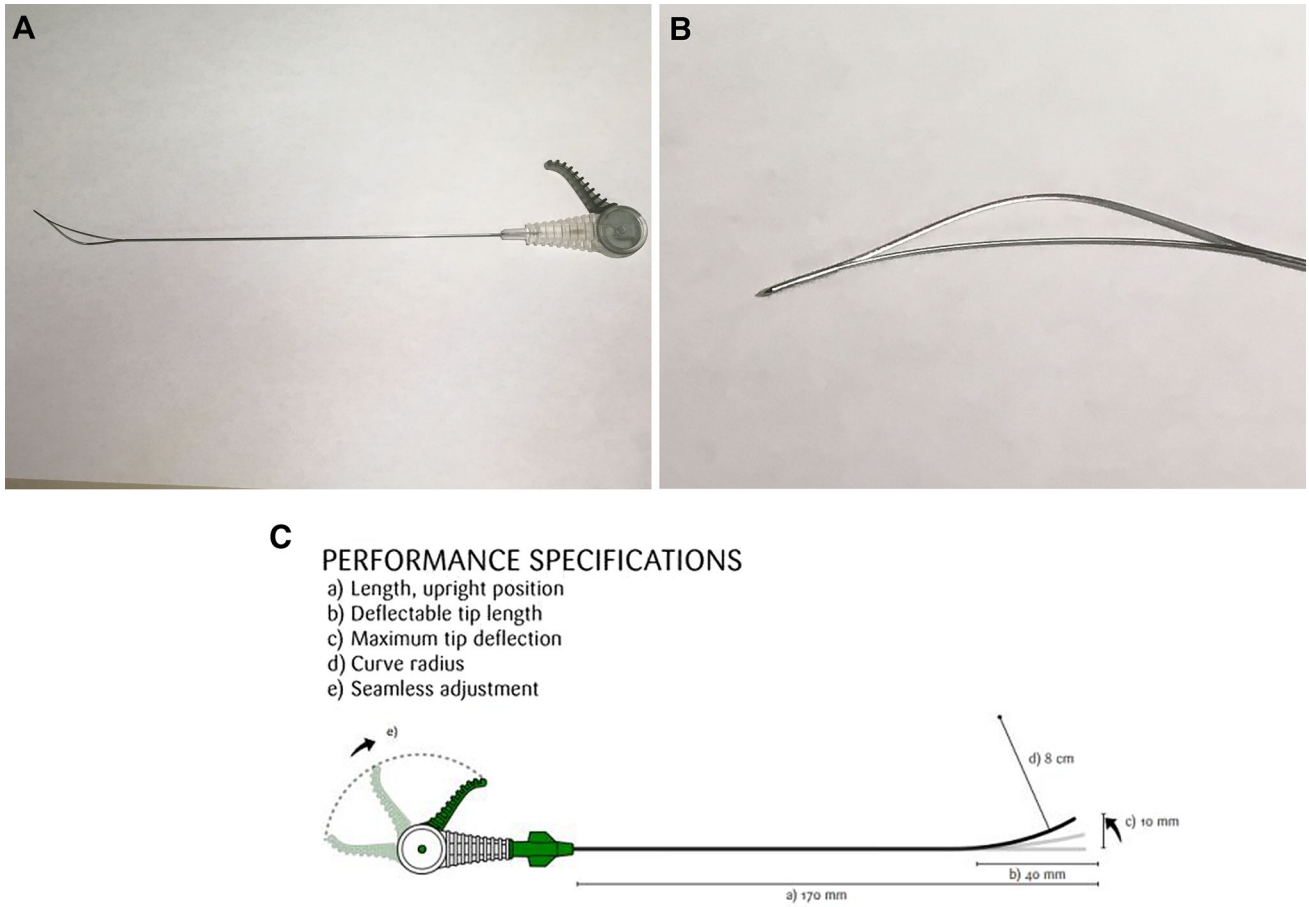

Fig. 1. **A** Image of internal stylet from the steerable needle when "bent" by turning the lever. **B** Close-up of stylet tip in "A". **C** Diagram showing the performance specifications (courtesy Apriomed with permission) of the steerable needle with stylet in place, including its range of motion.

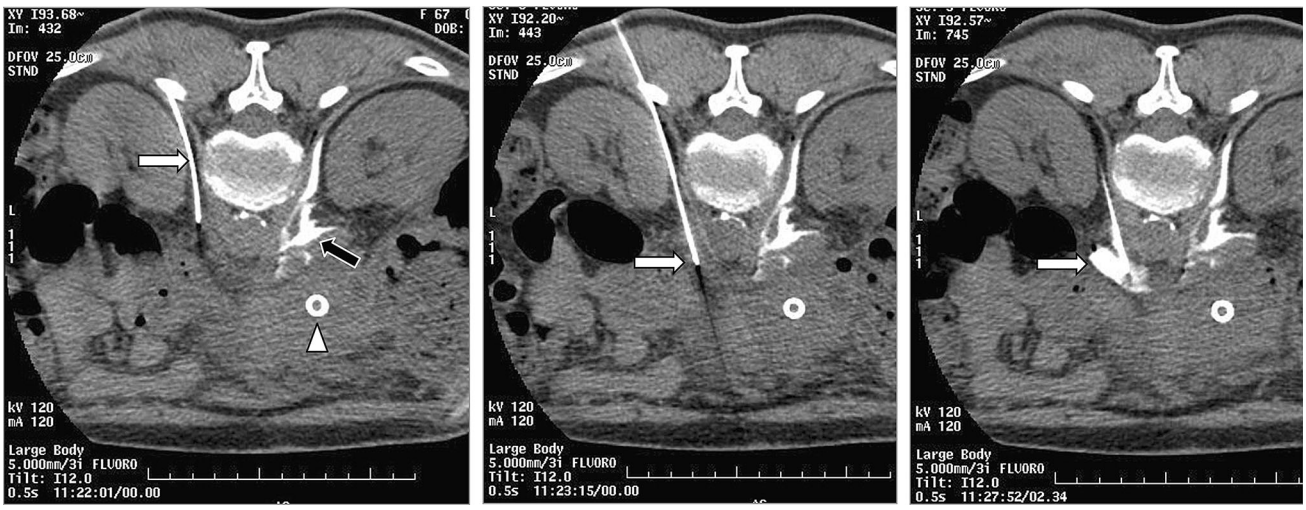

Fig. 2. Patient with recalcitrant pain from invasive pancreatic ductal adenocarcinoma. **A** Left celiac blockade performed with patient prone. Steerable needle curved around the left kidney (white arrow). Gantry tilt was 12° caudal. Large pancreatic infiltrating mass with biliary stent (white arrowhead). Contrast agent from previous right-side injection (black arrow). **B** Final needle tip position is shown (white arrow). **C** Initial injection of contrast medium and neurolytic agent (white arrow).

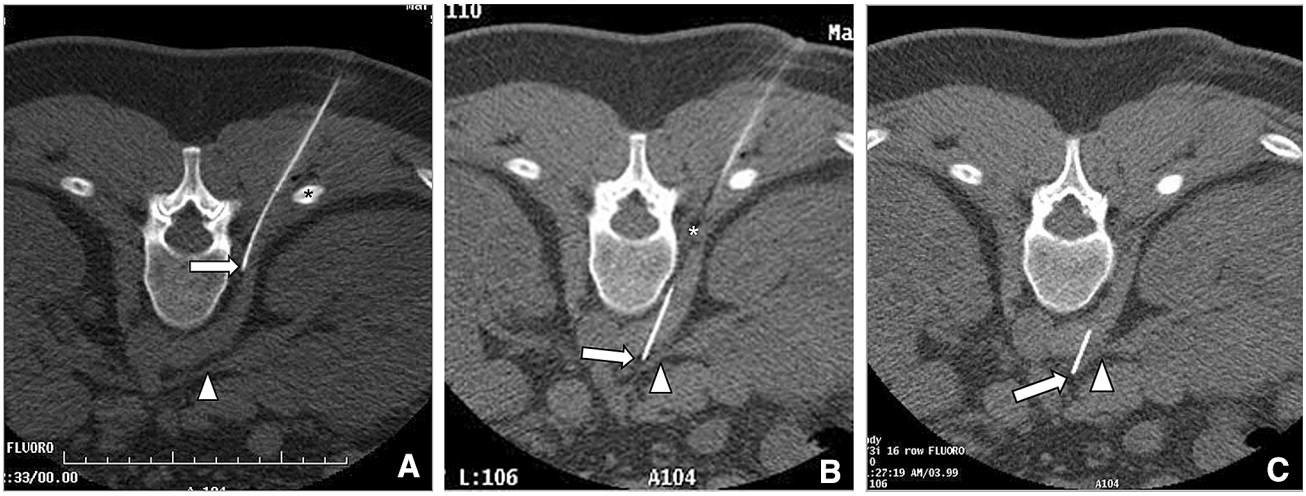

Fig. 3. Patient with chronic, recalcitrant right flank pain from autosomal dominant polycystic kidney disease. **A** Right aorticorenal blockade performed with patient prone. To avoid the kidney, an approach medial to the rib (black asterisk) is chosen. Using the steerable curve, the needle (white arrow) is manipulated around the spine. Right renal vein, inferior vena cava, and left renal vein are shown in plane (white arrowhead is left renal vein). **B** The needle is advanced using the curve to direct it superiorly, causing the mid portion of the needle to be out of plane (white asterisk). **C** Continuing to use the superiorly directed curve, the needle was positioned above the left renal vein insertion into the inferior vena cava (white arrowhead); final needle position is shown (white arrow).

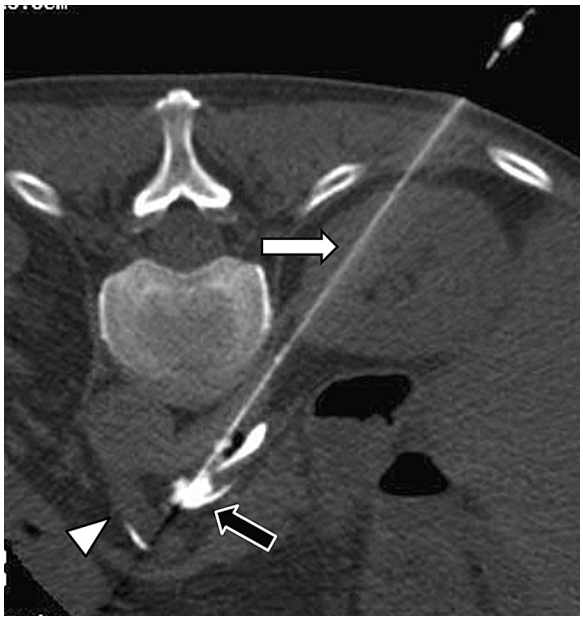

Fig. 4. Patient with advanced metastatic cancer in the abdomen and malignant small bowel obstruction. Temporary celiac blockade performed for ongoing refractory pain. Using a standard 21 gauge needle with patient prone, the right kidney was traversed (white arrow). Contrast from the injection is seen coming from the needle tip (black arrow) at the level of the superior mesenteric artery origin (white arrowhead).

tients had undergone permanent blocks performed with the standard needle. The first patient had diarrhea and continued pain for 1 week before relief. The second patient had increased pain for 3 days before relief. Neither patient was admitted to or evaluated in the emergency department. There were no complications felt to be related to the needle placement itself (e.g., traversing the kidney). We found no significant difference in complications between the steerable needle group and standard needle group ($P = 0.56$).

Discussion

Avoidance of the kidneys or IVC during procedures is always preferable and could save a patient a medical complication or discomfort. However, the aim of this report is to demonstrate the use of the steerable needle to avoid an intervening structure, using the kidneys as the specific example.

In the present study, we report that steerable needles allowed the operator to avoid traversing the kidneys in all cases. Specifically, before use of the steerable needle, a kidney was traversed in 4 of 10 cases, whereas with the steerable needle, none of 13 kidneys was traversed ($P = 0.02$). We also observed ability to avoid hypertrophied adrenal glands, renal veins, and the IVC and to navigate around the spine, if needed (Fig. 3). This outcome makes for a potentially safer and technically precise procedure.

The downside of the steerable needle is that it currently comes only in a 17-cm length, which can be difficult to fit in the CT gantry for viewing on initial insertion. In addition, the stylet does not currently lock to the hub of the needle, requiring fixation by the operator as it is advanced. Of note, the needle is useful for

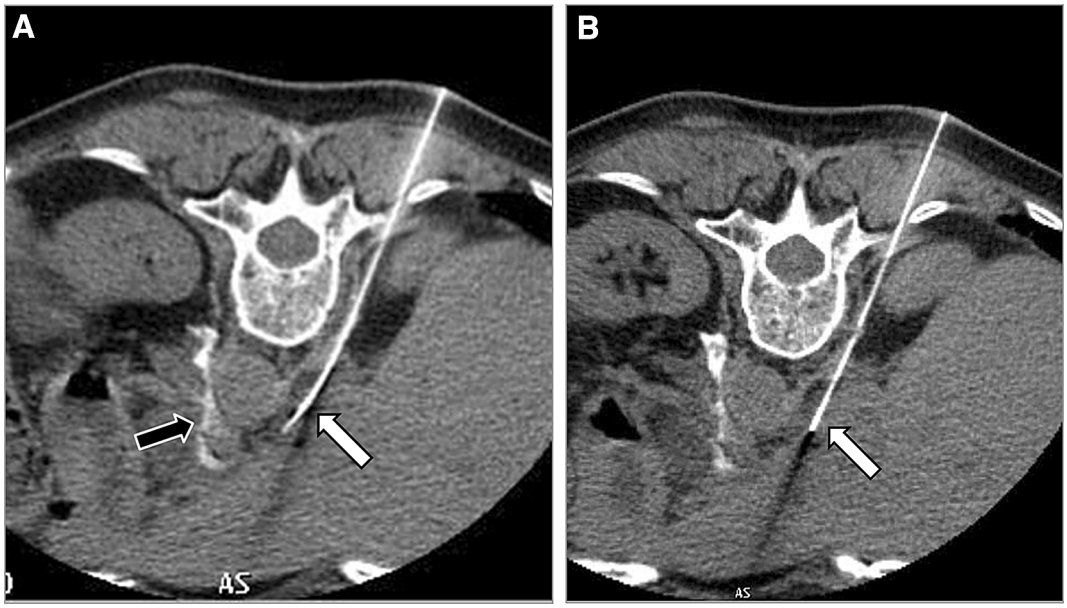

Fig. 5. Patient with recalcitrant pain from metastatic pancreatic adenocarcinoma. **A** Patient in prone position. Contrast medium (black arrow) from previous left block. Needle on right with tip curved into preferred location (white arrow). **B** After release of curve and removal of the stylet, the needle tip (white arrow) straightened and pulled back slightly. The steerable needle was not considered beneficial in this case.

guidance along a curved path, but the final needle position will be straighter after the stylet is removed. The curve of the needle with no advancement will not persist after the stylet is removed (Fig. 5).

Other potential techniques are to curve around bony structures or bowel for drainage access or fine-needle aspiration. We successfully have used the curve of the steerable needle to obtain access into fluid collections, to avoid traversing the liver, or to provide a more perpendicular approach for puncturing a thick-walled abscess. A 21-gauge needle can be used for fine-needle aspiration. Developing a larger-gauge steerable needle may be of benefit for use as a guide needle for biopsy when difficult cases develop. Manual steering with a beveled stylet or curving the needle have been used in the past, allowing the operator to change the course of the needle slightly due to deflection. Curved needles have been reported to be useful for fine-needle aspiration and hydrodissection [12–14]. An advantage of the needle evaluated in this study is the needle allows for the direction to be change more than once as it is advanced. The disadvantage is that the distal needle does not remain curved after the stylet is removed, as discussed above, unlike a permanently curved needle. Other steerable needle concepts have been reported in the literature prior to clinical use including those that use robotics, but other needles were not evaluated in this study nor was comparison to other needle prototypes a part of this study [15].

The main limitation of this review is its retrospective non-randomized design of a sole operator experience, with potential for inherent bias, and small sample size.

Conclusion

The steerable needle evaluated in this study was found to be useful for avoiding the kidneys when targeting the celiac or aorticorenal plexus. This suggests it may also be useful for avoiding other structures during other procedures, and further study is encouraged.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval For this type of study formal consent is not required.

Informed consent Does not apply.

Disclosures J.S.K. designed the study and gathered the data. J.S.K. and N.Z. analyzed the data. All authors vouch for the data and the analysis, wrote the paper, and decided to publish the paper. No study sponsor. No pertinent disclosures.

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